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AGREEMENT

CONCERNING THE ADOPTION OF UNIFORM TECHNICAL PRESCRIPTIONS FOR WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN BE FITTED AND/OR BE USED ON WHEELED VEHICLES AND THE CONDITIONS FOR RECIPROCAL RECOGNITION OF APPROVALS GRANTED ON THE BASIS OF THESE PRESCRIPTIONS */

(Revision 2, including the amendments entered into force on 16 October 1995)

Addendum 12H: Regulation No. 13-H

Date of entry into force: 11 May 1998

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING

UNITED NATIONS

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*/ Former title of the Agreement:

Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts, done at Geneva on 20 March 1958.

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Regulation No. 13-H

UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING

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1. SCOPE

1.1 This Regulation applies to the braking of vehicles of category M1, as defined in annex 7 to the Consolidated Resolution on the Construction of Vehicles (R.E.3). 1/ */

1.2 This Regulation does not cover:

1.2.1. vehicles with a design speed not exceeding 25 km/h;

1.2.2. vehicles fitted for invalid drivers.

2. DEFINITIONS

For the purposes of this Regulation,

2.1. "Approval of a vehicle" means the approval of a vehicle type with regard to braking.

2.2. "Vehicle type" means a category of vehicles which do not differ in such essential respects as:

2.2.1. the maximum mass, as defined in paragraph 2.11. below;

2.2.2. the distribution of mass among the axles;

2.2.3. the maximum design speed;

2.2.4. a different type of braking equipment, with more particular reference to the presence or otherwise of equipment for braking a trailer or any presence of electric braking system;

2.2.5. the engine type;

2.2.6. the number and ratios of gears;

2.2.7. the final drive ratios;

2.2.8. the tyre dimensions.

2.3. "Braking equipment" means the combination of parts whose function is progressively to reduce the speed of a moving vehicle or bring it to a halt, or to keep it stationary if it is already halted; these functions are specified in paragraph 5.1.2. below. The

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1/ Document TRANS/WP.29/78/Rev.1.

*/ This Regulation offers an alternative set of requirements for category M1 vehicles to those contained in Regulation No. 13. Contracting Parties that are signatories to both Regulation No. 13 and this Regulation recognize approvals to either Regulation as equally valid.

equipment consists of the control, the transmission, and the brake proper.

2.4. "Control" means the part actuated directly by the driver to furnish to the transmission the energy required for braking or controlling it. This energy may be the muscular energy of the driver, or energy from another source controlled by the driver, or a combination of these various kinds of energy.

2.5. "Transmission" means the combination of components comprised between the control and the brake and linking them functionally. The transmission may be mechanical, hydraulic, pneumatic, electric or mixed. Where the braking power is derived from or assisted by a source of energy independent of the driver but controlled by him, the reserve of energy in the system is likewise part of the transmission;

The transmission is divided into two independent functions: the control transmission and the energy transmission. Whenever the term "transmission" is used alone in this Regulation, it means both the "control transmission" and the "energy transmission":

2.5.1. "Control transmission" means the combination of the components of the transmission which control the operation of the brakes, including the control function and the necessary reserve(s) of energy;

2.5.2. "Energy transmission" means the combination of the components which supply to the brakes the necessary energy for their function, including the reserve(s) of energy necessary for the operation of the brakes.

2.6. "Brake" means the part in which the forces opposing the movement of the vehicle develop. It may be a friction brake (when the forces are generated by friction between two parts of the vehicle moving relatively to one another); an electrical brake (when the forces are generated by electro-magnetic action between two parts of the vehicle moving relatively to but not in contact with one another); a fluid brake (when the forces are generated by the action of a fluid situated between two parts of the vehicle moving relatively to one another); or an engine brake (when the forces are derived from an artificial increase in the braking action, transmitted to the wheels, of the engine).

2.7. "Different types of braking equipment" means equipment which differ in such essential respects as:

2.7.1. components having different characteristics;

2.7.2. a component made of materials having different characteristics, or a component differing in shape or size;

2.7.3. a different assembly of the components.

2.8. "Component of the braking equipment" means one of the individual parts which, when assembled, constitute the braking equipment;

2.9. "Progressive and graduated braking" means braking during which, within the normal operating range of the device, and during actuation of the brakes (see paragraph 2.16. below):

2.9.1. the driver can at any moment increase or decrease the braking force by acting on the control;

2.9.2. the braking force varies proportionally as the action on the control (monotonic function);

2.9.3. the braking force can be easily regulated with sufficient precision.

2.10. "Laden vehicle" means, except where otherwise stated, a vehicle so laden as to attain its "maximum mass".

2.11. "Maximum mass" means the maximum mass stated by the vehicle manufacturer to be technically permissible (this mass may be higher than the "permissible maximum mass" laid down by the national administration).

2.12. "The distribution of mass among the axles" means the distribution of the effect of the gravity on the mass of the vehicle and/or its contents among the axles.

2.13. "Wheel/axle load" means the vertical static reaction (force) of the road surface in the contact area on the wheel/wheels of the axle.

2.14. "Maximum stationary wheel/axle load" means the stationary wheel/axle load achieved under the condition of the laden vehicle.

2.15. "Hydraulic braking equipment with stored energy" means a braking equipment where energy is supplied by a hydraulic fluid under pressure, stored in one or more accumulator(s) fed from one or more pressure pump(s), each fitted with a means of limiting the pressure to a maximum value. This value shall be specified by the manufacturer.

2.16. "Actuation" means both application and release of the control.

2.17. "Electric vehicle" means a vehicle in which the traction is effected only by (an) electric motor(s) acting at least on one axle;

2.17.1. "Electric regenerative braking system" means a braking system which allows the use of the vehicle's drive motor(s) to convert

the vehicle's kinetic energy into electrical energy during deceleration;

2.17.2. "Electric regenerative braking control" means a device which modulates the action of the electric regenerative braking system;

2.17.3. "Electric regenerative braking system of category A" means an electric regenerative braking system which is not part of the service braking system;

2.17.4. "Electric regenerative braking system of category B" means an electric regenerative braking system which is part of the service braking system;

2.17.5. "Electric state of charge" means the instantaneous ratio of electric quantity of energy stored in the traction battery relative to the maximum quantity of electric energy which could be stored in this battery;

2.17.6. "Traction battery" means an assembly of accumulators constituting the storage of energy used for powering the traction motor(s) of the vehicle.

2.18. "Nominal value" definitions for braking reference performance are required to put a value on the transfer function of the braking system, relating output to input for vehicles individually;

2.18.1. "Nominal value" is defined as the characteristic which can be demonstrated at Type Approval and which relates the braking rate of the vehicle on its own to the level of the braking input variable.

3. APPLICATION FOR APPROVAL

3.1. The application for approval of a vehicle type with regard to braking shall be submitted by the vehicle manufacturer or by his duly accredited representative.

3.2. It shall be accompanied by the undermentioned documents in triplicate and by the following particulars:

3.2.1. a description of the vehicle type with regard to the items specified in paragraph 2.2. above. The numbers and/or symbols identifying the vehicle type and the engine type shall be specified;

3.2.2. a list of the components, duly identified, constituting the braking equipment;

3.2.3. a diagram of assembled braking equipment and an indication of the position of its components on the vehicle;

3.2.4. detailed drawings of each component to enable it to be easily located and identified.

3.3. A vehicle, representative of the vehicle type to be approved, shall be submitted to the Technical Service conducting the approval tests.

4. APPROVAL

4.1. If the vehicle type submitted for approval pursuant to this Regulation meets the requirements of paragraphs 5 and 6 below, approval of that vehicle type shall be granted.

4.2. An approval number shall be assigned to each type approved, its first two digits shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same number to the same vehicle type equipped with another type of braking equipment, or to another vehicle type.

4.3. Notice of approval or of refusal of approval of a vehicle type pursuant to this Regulation shall be communicated to the Parties to the Agreement which apply this Regulation by means of a form conforming to the model in annex 1 to this Regulation and of a summary of the information contained in the documents referred to in paragraphs 3.2.1. to 3.2.4. above, the drawings supplied by the applicant for approval being in a format not exceeding A4 (210 x 297 mm), or folded to that format, and on an appropriate scale.

4.4. There shall be affixed, conspicuously and in a readily accessible place specified on the approval form, to every vehicle conforming to a vehicle type approved under this Regulation, an international approval mark consisting of:

4.4.1. a circle surrounding the letter "E" followed by the distinguishing number of the country which has granted approval 2/, and of

4.4.2. the number of this Regulation, followed by the letter "R", a dash and the approval number to the right of the circle prescribed in paragraph 4.4.1. above.

4.5. If the vehicle conforms to a vehicle type approved under one or more other Regulations, annexed to the Agreement, in the country which has granted approval under this Regulation, the symbol prescribed in paragraph 4.4.1. above, need not be repeated; in such a case, the Regulation and approval numbers and the additional symbols of all the regulations under which approval has been granted in the country which has granted approval under this Regulation shall be placed in vertical columns to the right of the symbol prescribed in paragraph 4.4.1. above.

4.6. The approval mark shall be clearly legible and be indelible.

4.7. The approval mark shall be placed close to or on the vehicle data plate.

4.8. Annex 2 to this Regulation gives examples of arrangements of approval marks.

5. SPECIFICATIONS

5.1. General

5.1.1. Braking equipment

5.1.1.1. The braking equipment shall be so designed, constructed and fitted as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the provisions of this Regulation.

2/ 1 for Germany, 2 for France, 3 for Italy, 4 for the Netherlands, 5 for Sweden, 6 for Belgium, 7 for Hungary, 8 for the Czech Republic, 9 for Spain, 10 for Yugoslavia, 11 for the United Kingdom, 12 for Austria, 13 for Luxembourg, 14 for Switzerland, 15 (vacant), 16 for Norway, 17 for Finland, 18 for Denmark, 19 for Romania, 20 for Poland, 21 for Portugal, 22 for the Russian Federation, 23 for Greece, 24 (vacant), 25 for Croatia, 26 for Slovenia, 27 for Slovakia, 28 for Belarus, 29 for Estonia, 30 (vacant), 31 for Bosnia and Herzegovina, 32-36 (vacant), 37 for Turkey, 38-39 (vacant) and 40 for the Former Yugoslav Republic of Macedonia. Subsequent numbers shall be assigned to other countries in the chronological order in which they ratify or accede to the Agreement concerning the Recognition of Approval for Motor Vehicle Equipment and Parts, and the numbers thus assigned shall be communicated by the Secretary-General of the United Nations to the Contracting Parties to the Agreement.

5.1.1.2. In particular, the braking equipment shall be so designed, constructed and fitted as to be able to resist the corroding and ageing phenomena to which it is exposed.

5.1.1.3. Brake linings shall not contain asbestos.

5.1.1.4. The effectiveness of the braking equipment shall not be adversely affected by magnetic or electrical fields. (This shall be demonstrated by compliance with Regulation No. 10, 02 series of amendments.)

5.1.1.5. It shall be possible to generate maximum braking forces under static conditions on a rolling road or roller brake tester.

5.1.1.6. A failure detection signal may interrupt momentarily (< 10 ms) the demand signal in the control transmission, provided that the braking performance is thereby not reduced.

5.1.2. Functions of the braking equipment

The braking equipment defined in paragraph 2.3. must fulfil the following functions:

5.1.2.1. Service braking system

The service braking system must make it possible to control the movement of the vehicle and to halt it safely, speedily and effectively, whatever its speed and load, on any up or down gradient. It must be possible to graduate this braking action. The driver must be able to achieve this braking action from his driving seat without removing his hands from the steering control.

5.1.2.2. Secondary braking system

The secondary braking system must make it possible by application of the service brake control to halt the vehicle within a reasonable distance in the event of failure of the service braking system. It must be possible to graduate this braking action. The driver must be able to obtain this braking action from his driving seat without removing his hands from the steering control. For the purposes of these provisions it is assumed that not more than one failure of the service braking system can occur at one time.

5.1.2.3. Parking braking system

The parking braking system must make it possible to hold the vehicle stationary on an up or down gradient even in the absence of the driver, the working parts being then held in the locked position by a purely mechanical device. The driver must be able to achieve this braking action from his driving seat.

5.2. Characteristics of braking systems

5.2.1. The set of braking systems with which a vehicle is equipped must satisfy the requirements laid down for service, secondary and parking braking systems.

5.2.2. The systems providing service, secondary and parking braking may have common components so long as they fulfil the following conditions:

5.2.2.1. there must be at least two controls, independent of each other and readily accessible to the driver from his normal driving position. Every brake control shall be designed such that it returns to the fully off position when released. This requirement shall not apply to a parking brake control when it is mechanically locked in an applied position;

5.2.2.2. the control of the service braking system must be independent of the control of the parking braking system;

5.2.2.3. the effectiveness of the linkage between the control of the service braking system and the different components of the transmission systems must not be liable to diminish after a certain period of use;

5.2.2.4. the parking braking system must be so designed that it can be actuated when the vehicle is in motion;

5.2.2.5. in the event of breakage of any component other than the brakes (as defined in paragraph 2.6. above) and the components referred to in paragraph 5.2.2.8. below, or of any other failure of the service braking system (malfunction, partial or total exhaustion of an energy reserve), that part of the service braking system which is not affected by the failure, must be able to bring the vehicle to a halt in the conditions prescribed for secondary braking;

5.2.2.6. if service braking is ensured by the action of the driver's muscular energy assisted by one or more energy reserves, secondary braking must, in the event of failure of that assistance, be capable of being ensured by the driver's muscular energy assisted by the energy reserves, if any, which are unaffected by the failure, the force applied to the service brake control not exceeding the prescribed maximum;

5.2.2.7. if the service braking force and transmission depend exclusively on the use, controlled by the driver, of an energy reserve, there must be at least two completely independent energy reserves, each provided with its own transmission, likewise independent; each of them may act on the brakes of only two or more wheels so selected as to be capable of ensuring by themselves the prescribed degree of secondary braking without endangering the stability of the

vehicle during braking; in addition, each of the aforesaid energy reserves must be equipped with a warning device as defined in paragraph 5.2.14. below;

5.2.2.8. certain parts, such as the pedal and its bearing, the master cylinder and its piston or pistons, the control valve, the linkage between the pedal and the master cylinder or the control valve, the brake cylinders and their pistons, and the lever-and-cam assemblies of brakes, shall not be regarded as liable to breakage if they are amply dimensioned, are readily accessible for maintenance, and exhibit safety features at least equal to those prescribed for other essential components (such as the steering linkage) of the vehicle. Any such part as aforesaid whose failure would make it impossible to brake the vehicle with a degree of effectiveness at least equal to that prescribed for secondary braking must be made of metal or of a material with equivalent characteristics and must not undergo notable distortion in normal operation of the braking systems.

5.2.3. The failure of a part of a hydraulic transmission system shall be signalled to the driver by a device comprising a red tell-tale signal lighting up before or upon application of a differential pressure of not more than 15.5 bar between the active and failed brake equipment, measured at the master cylinder outlet and remaining lit as long as the failure persists and the ignition (start) switch is in the "on" (run) position. However, a device comprising a red tell-tale signal lighting up when the fluid in the reservoir is below a certain level specified by the manufacturer is permitted. The tell-tale signal must be visible even by daylight; the satisfactory condition of the signal must be easily verifiable by the driver from the driver's seat. The failure of a component of the device must not entail total loss of the braking equipment's effectiveness. Application of the parking brake must also be indicated to the driver. The same tell-tale signal may be used.

5.2.4. Where use is made of energy other than the muscular energy of the driver, there need not be more than one source of such energy (hydraulic pump, air compressor, etc.), but the means by which the device constituting that source is driven must be as safe as practicable.

5.2.4.1. In the event of failure in any part of the transmission of a braking system, the feed to the part not affected by the failure must continue to be ensured if required for the purpose of halting the vehicle with the degree of effectiveness prescribed for secondary braking. This condition must be met by means of devices which can easily be actuated when the vehicle is stationary, or by automatic means.

5.2.4.2. Furthermore, storage devices located down-circuit of this device must be such that in the case of a failure in the energy supply

after four full-stroke actuations of the service brake control, under the conditions prescribed in paragraph 1.2. of annex 4 to this Regulation, it is still possible to halt the vehicle at the fifth application, with the degree of effectiveness prescribed for secondary braking.

5.2.4.3. However, for hydraulic braking systems with stored energy, these provisions can be considered to be met provided that the requirements of paragraph 1.3. of annex 4 to this Regulation, are satisfied.

5.2.5. The requirements of paragraphs 5.2.2., 5.2.3. and 5.2.4. above must be met without the use of any automatic device of a kind such that its ineffectiveness might pass unnoticed through the fact that parts normally in a position of rest come into action only in the event of failure in the braking system.

5.2.6. The service braking system shall act on all the wheels of the vehicle.

5.2.7. The action of the service braking system shall be appropriately distributed among the axles.

5.2.8. The action of the service braking system shall be distributed between the wheels of one and the same axle symmetrically in relation to the longitudinal median plane of the vehicle. Compensation and functions, such as anti-lock, which may cause deviations from this symmetrical distribution, and functions, such as traction control, which may cause application of the brakes not directly controlled by the driver, shall be declared. 1/

5.2.8.1. Compensation by the electric control transmission for deterioration or defect within the braking system shall be indicated to the driver by means of the yellow warning signal specified in paragraph 5.2.21.1.2. below. This requirement shall apply for all conditions of loading when compensation exceeds the following limits:

5.2.8.1.1. a difference in transverse braking pressures on any axle:

(a) of 25 per cent of the higher value for vehicle decelerations $\geq$ 2 m/sec^2,

(b) a value corresponding to 25 per cent at 2 m/sec^2 for decelerations below this rate.

1/ Adequate performance specifications and the associated test procedures shall be presented by the manufacturer and shall be subject to discussion and agreement by the Technical Service (unless already covered by the present Regulation). For this purpose, the manufacturer shall provide documentation which covers: system layout, description of functions and safety concept.

5.2.8.1.2. an individual compensating value on any axle:

(a) > 50 per cent of the nominal value for vehicle decelerations ≥ 2 m/sec^2,

(b) a value corresponding to 50 per cent of the nominal value at 2 m/sec^2 for decelerations below this rate.

5.2.8.2. Compensation as defined above, is permitted only when the initial brake application is made at vehicle speeds greater than 10 km/h.

5.2.9. Malfunctions of the electric control transmission shall not apply the brakes contrary to the driver's intentions.

5.2.10. The service braking equipment and the parking braking equipment must act on braking surfaces permanently connected to the wheels through components of adequate strength. No braking surface shall be capable of being disconnected from the wheels; however, in the case of the service braking system and the secondary braking system, such disconnection of the braking surfaces shall be permitted provided that it is only momentary, for instance, during a change of gear, and that both the service braking and the secondary braking continue to operate with the prescribed degree of effectiveness. In addition, disconnections as aforesaid shall be permitted in the case of the parking braking system on condition that it is controlled exclusively by the driver from his driving seat by a system incapable of being brought into action by a leak.

5.2.11. Wear of the brakes must be capable of being easily taken up by means of a system of manual or automatic adjustment. In addition, the control and the components of the transmission and of the brakes must possess a reserve of travel and, if necessary, suitable means of compensation such that, when the brakes become heated, or the brake linings have reached a certain degree of wear, effective braking is ensured without immediate adjustment being necessary.

5.2.11.1. Wear adjustment shall be automatic for the service brakes. Automatic wear adjustment devices shall be such that after heating followed by cooling of the brakes, effective braking is still ensured. In particular the vehicle shall remain capable of normal running after the tests conducted in accordance with annex 3, paragraph 1.5. (Type-I test).

5.2.11.2. It shall be possible to easily check this wear on service brake linings from the outside or underside of the vehicle utilizing only the tools or equipment normally supplied with the vehicle, for instance, by the provision of appropriate inspection holes or by some other means. Alternatively, acoustic or optical devices warning the driver at his driving position when lining replacement is necessary are acceptable. The removal of front and/or rear

wheels is permitted for this purpose. The yellow warning signal specified in paragraph 5.2.21.1.2. below may be used as the optical warning signal.

5.2.12. In hydraulic-transmission braking systems, the filling ports of the fluid reservoirs must be readily accessible; in addition, the receptacles containing the reserve fluid must be so designed and constructed that the level of the reserve fluid can be easily checked without the receptacles having to be opened, and the minimum total reservoir capacity is equivalent to the fluid displacement resulting when all the wheel cylinders or calliper pistons serviced by the reservoirs move from a new lining, fully retracted position to a fully worn, fully applied position. If these latter conditions are not fulfilled, the red warning signal specified in paragraph 5.2.21.1.1. below shall draw the driver's attention to any fall in the level of reserve fluid liable to cause a failure of the braking system.

5.2.13. The type of fluid to be used in hydraulic transmission braking systems shall be identified by the symbol in accordance with figure 1 or 2 of ISO Standard 9128 - 1987 and the symbol DOT3/DOT4/DOT5, as appropriate. The symbols must be affixed in a visible position in indelible form within 100 mm of the filling ports of the fluid reservoirs; additional information may be provided by the manufacturer.

5.2.14. Warning device

5.2.14.1. Any vehicle fitted with a service brake actuated from an energy reservoir must, where the prescribed secondary braking performance cannot be obtained by means of this brake without the use of the stored energy, be provided with a warning device, giving an optical or acoustic signal when the stored energy, in any part of the system, falls to a value at which without re-charging of the reservoir and irrespective of the load conditions of the vehicle, it is possible to apply the service brake control a fifth time after four full-stroke actuations and obtain the prescribed secondary braking performance (without faults in the service brake transmission device and with the brakes adjusted as closely as possible). This warning device must be directly and permanently connected to the circuit. When the engine is running under normal operating conditions and there are no faults in the braking system, as is the case in type approval tests, the warning device must give no signal except during the time required for charging the energy reservoir(s) after start-up of the engine. The red warning signal specified in paragraph 5.2.21.1.1. below shall be used as the optical warning signal.

5.2.14.2. However, in the case of vehicles which are only considered to comply with the requirements of paragraph 5.2.4.1. of this Regulation by virtue of meeting the requirements of paragraph 1.3. of annex 4 to this Regulation, the warning device shall consist of

an acoustic signal in addition to an optical signal. These devices need not operate simultaneously, provided that each of them meets the above requirements and the acoustic signal is not actuated before the optical signal. The red warning signal specified in paragraph 5.2.21.1.1. below shall be used as the optical warning signal.

5.2.14.3. This acoustic device may be rendered inoperative while the parking brake is applied and/or, at the choice of the manufacturer, in the case of automatic transmission the selector is in the "Park" position.

5.2.15. Without prejudice to the requirements of paragraph 5.1.2.3. above, where an auxiliary source of energy is essential to the functioning of a braking system, the reserve of energy must be such as to ensure that, if the engine stops or in the event of a failure of the means by which the energy source is driven, the braking performance remains adequate to bring the vehicle to a halt in the prescribed conditions. In addition, if the muscular effort applied by the driver to the parking braking system is reinforced by a servo device, the actuation of parking braking must be ensured in the event of a failure of the servo device, if necessary by using a reserve of energy independent of that normally supplying the servo device. This reserve of energy may be that intended for the service braking system.

5.2.16. The pneumatic/hydraulic auxiliary equipment must be supplied with energy in such a way that during its operation the prescribed deceleration values can be reached and that even in the event of damage to the source of energy the operation of the auxiliary equipment cannot cause the reserves of energy feeding the braking systems to fall below the level indicated in paragraph 5.2.14. above.

5.2.17. In the case of a motor vehicle equipped to tow a trailer with electric service brakes, the following requirements shall be met:

5.2.17.1. the power supply (generator and battery) of the motor vehicle shall have a sufficient capacity to provide the current for an electric braking system. With the engine running at the idling speed recommended by the manufacturer and all electrical devices supplied by the manufacturer as standard equipment of the vehicle switched on, the voltage in the electrical lines shall at maximum current consumption of the electrical braking system (15 A) not fall below the value of 9.6V measured at the connection. The electrical lines shall not be capable of short circuiting even when overloaded;

5.2.17.2. in the event of a failure in the motor vehicle's service braking system, where that system consists of at least two independent units, the unit or units not affected by the failure shall be capable of partially or fully actuating the brakes of the trailer;

5.2.17.3. the use of the stop-lamp switch and circuit for actuating the electrical braking system is permissible only if the actuating line is connected in parallel with the stop-lamp and the existing stop-lamp switch and circuit are capable of taking the extra load.

5.2.18. Additional requirements for electric vehicles:

5.2.18.1. Electric vehicles fitted with an electric regenerative braking system of category A;

5.2.18.1.1. the electric regenerative braking shall only be activated by the accelerator control and/or the gear neutral position.

5.2.18.2. Electric vehicles fitted with an electric regenerative braking system of category B;

5.2.18.2.1. it must not be possible to disconnect partially or totally one part of the service braking system other than by an automatic device;

5.2.18.2.2. the service braking system must have only one control device;

5.2.18.2.3. the service braking system must not be adversely affected by the disengagement of the motor(s) or by the gear ratio used;

5.2.18.2.4. if the operation of the electric component of braking is ensured by a relation established between information coming from the control of the service brake and the braking force to the wheels which of it results, a failure of this relation leading to the non-respect of the prescriptions of distribution of braking among the axles (annex 5 or 6, which is applicable) must be warned to the driver by an optical warning signal at the latest when the control is actuated and having to remain lit as long as this defect exists and that the switch of "contact" is in the position "go".

5.2.18.3. For electric vehicles fitted with an electric regenerative braking system of both categories, all the relevant prescriptions shall apply except paragraph 5.2.18.1.1. above. In this case, the electric regenerative braking may be actuated by the accelerator control and/or the gear neutral position. Additionally, the action on the service braking control must not reduce the above braking effect generated by the release of the accelerator control;

5.2.18.4. The operation of the electric braking must not be adversely affected by magnetic or electric fields;

5.2.18.5. For vehicles equipped with an anti-lock device, the anti-lock device must control the electric braking system.

5.2.19. Special additional requirements for the electric transmission of the parking braking system:

5.2.19.1. In the case of a failure within the electric transmission, any unintended actuation of the parking braking system shall be prevented;

5.2.19.2. In the case of a break in the wiring within the electric control transmission, it shall remain possible to apply the parking braking system from the driver's seat and achieve the parking braking performance specified in paragraph 2.3.1. of annex 3 to this Regulation. It shall also be possible to release the parking braking system, if necessary by the use of an auxiliary release device carried/fitted on the vehicle. The engine/manual transmission or the automatic transmission (park position) may be used to achieve the above performance;

5.2.19.2.1. A break in the supply of electricity and/or in the wiring within the electric transmission of the parking braking system shall be signalled to the driver by the yellow warning signal specified in paragraph 5.2.21.1.2. below.

5.2.19.3. Auxiliary equipment may draw its energy from the energy reserve of the electric transmission of the parking braking system, provided that the actuation of the parking braking system will not be affected. In addition, where the energy reserve is also used by the service braking system, the requirements of paragraph 5.2.20.6. below shall apply;

5.2.19.4. After the ignition/start switch which controls the electrical energy for the braking equipment has been switched off and/or the key removed, it shall remain possible to apply the parking braking system, whereas releasing shall be prevented.

5.2.20. Special additional requirements for service braking systems with electric control transmission:

5.2.20.1. With the parking brake released, the service braking system shall be able to generate a static total braking force at least equivalent to that produced during the Type-0 test, even when the ignition/start switch has been switched off and/or the key has been removed. It should be understood that sufficient energy is available in the energy transmission of the service braking system;

5.2.20.2. In the case of a single temporary failure (< 40 ms) within the electric control transmission (e.g. non-transmitted signal or data error) there shall be no distinguishable effect on the service braking performance;

5.2.20.3. A continuous failure (≥ 40 ms) within the electric control transmission 4/, excluding its energy reserve shall be indicated to the driver by the red or yellow warning signal specified in paragraphs 5.2.21.1.1. and 5.2.21.1.2. below, respectively, as appropriate. When the prescribed service braking performance can no longer be achieved (red warning signal), failures resulting from a loss of electrical continuity (e.g. breakage, disconnection) shall be signalled to the driver as soon as they occur, and the prescribed residual braking performance shall be fulfilled by operating the service braking control in accordance with paragraph 2.2. of annex 3 to this Regulation. These requirements shall not be construed as a departure from the requirements concerning secondary braking.

5.2.20.4. In the event of a failure of the energy source of the electric control transmission, starting from the nominal value of the energy level, the full control range of the service braking system shall be guaranteed after twenty consecutive full stroke actuations of the service braking control. During the test, the braking control shall be fully applied for 20 seconds and released for 5 seconds on each actuation. It should be understood that during the above test sufficient energy is available in the energy transmission to ensure full actuation of the service braking system. This requirement shall not be construed as a departure from the requirements of annex 4.

5.2.20.5. When the battery voltage falls below a value nominated by the manufacturer at which the prescribed service braking performance can no longer be guaranteed and/or which precludes at least two independent service braking circuits from each achieving the prescribed secondary or residual braking performance, the red warning signal specified in paragraph 5.2.21.1.1. below shall be activated. After the warning signal has been activated, it shall be possible to apply the service braking control and obtain at least the residual performance prescribed in paragraph 2.2. of annex 3 to this Regulation. It should be understood that sufficient energy is available in the energy transmission of the service braking system. This requirement shall not be construed as a departure from the requirement concerning secondary braking.

5.2.20.6. If the auxiliary equipment is supplied with energy from the electric control transmission, the supply of the energy shall be sufficient to fulfil the prescribed deceleration values when all the auxiliary equipment is functioning. With the engine running at a speed not greater than 80% of the maximum power speed, the

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4/ Until uniform test procedures have been agreed, the manufacturer shall provide the Technical Service with an analysis of potential failures within the control transmission and their effects. This information shall be subject to discussion and agreement between the Technical Service and the vehicle manufacturer.

electric control transmission energy reserve shall not be discharged unless the prescribed deceleration values can be reached without the use of electrical energy. Compliance with this requirement may be demonstrated by calculation or by practical test.

5.2.20.7. If the auxiliary equipment is supplied with energy from the electric control transmission, the following requirements shall be fulfilled:

5.2.20.7.1. In the event of a failure in the energy source, whilst the vehicle is in motion, the energy in the reservoir shall be sufficient to actuate the brakes when the control is applied;

5.2.20.7.2. In the event of a failure in the energy source, whilst the vehicle is stationary and the parking braking system applied, the energy in the reservoir shall be sufficient to actuate the lights even when the brakes are applied.

5.2.21. Brake failure and defect warning signals (general requirements):

5.2.21.1. Motor vehicles shall be capable of providing optical brake failure and defect warning signals, as follows;

5.2.21.1.1. A red warning signal, indicating a failure within the vehicle braking equipment which precludes achievement of the prescribed service braking performance and/or which precludes the functioning of at least one of two independent service braking circuits;

5.2.21.1.2. Where applicable, a yellow warning signal indicating an electrically detected defect within the vehicle braking equipment, which is not indicated by the red warning signal described in paragraph 5.2.21.1.1. above.

5.2.21.2. The warning signals shall be visible, even by daylight; the satisfactory condition of the signals shall be easily verifiable by the driver from the driver's seat; the failure of a component of the warning devices shall not entail any loss of the braking system's performance.

5.2.21.3. A specified failure or defect shall be signalled to the driver by the above-mentioned warning signal(s) not later than on actuation of the service braking control. The warning signal(s) shall remain displayed as long as the failure/defect persists and the ignition (start) switch is in the "on" (run) position.

5.2.21.4. The warning signal(s) mentioned above shall light up when the electrical equipment of the vehicle (and the braking system) is energised. With the vehicle stationary, the braking system shall verify that none of the specified failures or defects are present before extinguishing the signals. Specified failures or defects which should activate the warning signals mentioned above, but

which are not detected under static conditions, shall be stored upon detection and be displayed at start-up and at all times when the ignition (start) switch is in the "on" (run) position, as long as the failure or defect persists.

6. TESTS

Braking tests which the vehicles submitted for approval are required to undergo, and the braking performance required, are described in annex 3 to this Regulation.

7. MODIFICATION OF VEHICLE TYPE OR BRAKING SYSTEM AND EXTENSION OF APPROVAL

7.1. Every modification of the vehicle type or of its braking system shall be notified to the administrative department which approved the vehicle type. That department may then either:

7.1.1. consider that the modifications made are unlikely to have an appreciable adverse effect and that in any case the vehicle still meets the requirements; or

7.1.2. require a further report from the Technical Service responsible for carrying out the tests.

7.2. Notice of confirmation, extension, or refusal of approval shall be communicated by the procedure specified in paragraph 4.3. above, to the Parties to the Agreement which apply this Regulation.

7.3. The competent authority issuing the extension of approval shall assign a series of numbers to each communication form drawn up for such an extension.

8. CONFORMITY OF PRODUCTION

The conformity of production procedures shall comply with those set out in the Agreement, Appendix 2 (E/ECE/324-E/ECE/TRANS/505/Rev.2) with the following requirements:

8.1. A vehicle approved to this Regulation shall be so manufactured as to conform to the type approved by meeting the requirements set forth in paragraph 5. above.

8.2. The authority which has granted type approval may at any time verify the conformity control methods applied in each production facility. The normal frequency of these verifications shall be once every two years.

9. PENALTIES FOR NON-CONFORMITY OF PRODUCTION

9.1. The approval granted in respect of a vehicle type pursuant to this Regulation may be withdrawn if the requirements laid down in paragraph 8.1. above are not complied with.

9.2. If a Contracting Party to the Agreement which applies this Regulation withdraws an approval it has previously granted, it shall forthwith so notify the other Contracting Parties applying this Regulation by means of a copy of the communication form conforming to the model in annex 1 to this Regulation.

10. PRODUCTION DEFINITELY DISCONTINUED

If the holder of the approval completely ceases to manufacture a type of vehicle approved in accordance with this Regulation, he shall so inform the authority which granted the approval. Upon receiving the relevant communication, that authority shall inform thereof the other Parties to the Agreement applying this Regulation by means of copies of a communication form conforming to the model in annex 1 to this Regulation.

11. NAMES AND ADDRESSES OF THE TECHNICAL SERVICES CONDUCTING APPROVAL TESTS, AND OF ADMINISTRATIVE DEPARTMENTS

The Parties to the Agreement applying this Regulation shall communicate to the United Nations secretariat the names and addresses of the technical services responsible for conducting approval tests and of the administrative departments which grant approval and to which forms, certifying approval or extension or refusal or withdrawal of approval, issued in other countries, are to be sent.

Annex 1

(maximum format: A4 (210 x 297 mm))

issued by: Name of Administration:
.....
.....
.....

concerning: 2/ APPROVAL GRANTED
APPROVAL EXTENDED
APPROVAL REFUSED
APPROVAL WITHDRAWN
PRODUCTION DEFINITELY DISCONTINUED

of a vehicle type with regard to braking, pursuant to Regulation No. 13-H

Approval No. . . . . Extension No. . . . . .

1. Trade name or mark of the vehicle . . . . . .
2. Vehicle type . . . . . .
3. Manufacturer's name and address . . . . . .
4. If applicable, name and address of manufacturer's representative . . . . . .
5. Mass of vehicle . . . . . .
5.1. Maximum mass of vehicle . . . . . .
5.2. Minimum mass of vehicle . . . . . .
6. Distribution of mass of each axle (maximum value) . . . . . .
7. Make and type of brake linings . . . . . .
7.1. Brake linings tested to all relevant prescriptions of annex 3 . . . .
7.2. Alternative brake linings tested to annex 7 . . . . . .
8. Engine type . . . . . .
9. Number and ratios of gears . . . . . .
10. Final drive ratio(s) . . . . . .
11. If applicable, maximum mass of trailer which may be coupled . . . . .
11.1. Unbraked trailer . . . . . .
12. Tyre dimension . . . . . .
12.1. Temporary-use spare wheel / tyre dimensions . . . . . .
12.2. Vehicle meets the technical requirements of annex 3 to Regulation No. 64: Yes/No 2/

1/ Distinguishing number of the country which has granted / extended / refused / withdrawn approval (see provisions in the Regulation).

2/ Strike out what does not apply.

13. Maximum design speed . . . . . .
14. Brief description of braking equipment . . . . . .
15. Mass of vehicle when tested: . . . . . .

	Laden (kg)	Unladen (kg)
Axle No. 1		
Axle No. 2		
Total		

16. Result of the tests:

TEST SPEED (km/h)	Measured Performance	Measured force applied to control (daN)

16.1. Type-0 tests,
engine disconnected
service braking (laden)
service braking (unladen)
secondary braking (laden)
secondary braking (unladen)

16.2. Type-0 tests,
engine connected
service braking (laden)
service braking (unladen)
(in accordance with paragraph 2.1.1. B of annex 3)

16.3. Type-I tests
preliminary snubs (to determine pedal force)
hot performance (1st stop)
hot performance (2nd stop)
recovery performance

16.4. Dynamic parking brake performance

17. Result of the annex 5 performance tests . . . . . .
18. Vehicle is / is not 2/ equipped to tow a trailer with electrical braking systems.
19. Vehicle is / is not 2/ equipped with an anti-lock system.
19.1. The vehicle fulfils the requirement of annex 6: Yes / No 2/
19.2. Category of anti-lock system: category 1 / 2 / 3 2/
20. Vehicle submitted for approval on . . . . . .
21. Technical Service responsible for conducting approval . . . . . .
22. Date of report issued by that Service . . . . . .
23. Number of report issued by that Service . . . . . .
24. Approval granted / refused / extended / withdrawn*
25. Position of approval mark on the vehicle . . . . . .
26. Place . . . . . .
27. Date . . . . . .
28. Signature . . . . . .
29. The summary referred to in paragraph 4.3. of this Regulation is annexed to this communication

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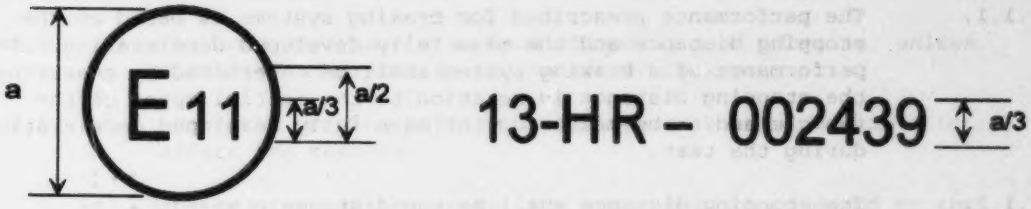
2/ Strike out what does not apply.

Annex 2

ARRANGEMENTS OF APPROVAL MARKS

Model A

(See paragraph 4.4. of this Regulation)

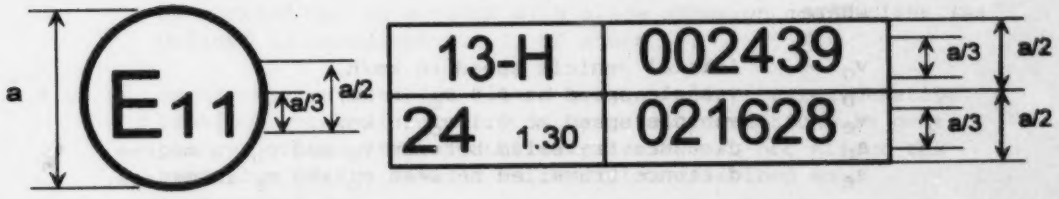


a = 8 mm min.

The above approval mark affixed to a vehicle shows that the vehicle type concerned has, with regard to braking, been approved in the United Kingdom (E11) pursuant to Regulation No. 13-H under approval number 002439. The first two digits of the approval number indicate that the approval was granted in accordance with the requirements of Regulation No. 13-H in its original form.

Model B

(See paragraph 4.5. of this Regulation)



a = 8 mm min.

The above approval mark affixed to a vehicle shows that the vehicle type concerned has been approved in the United Kingdom (E11) pursuant to Regulations Nos. 13-H and 24 1/. (In the case of the latter Regulation the corrected absorption coefficient is 1.30 m^{-1}). The approval numbers indicate that, at the dates when the respective approvals were given, Regulation No. 13-H was in its original form and Regulation No. 24 included the 02 series of amendments.

1/ This number is given merely as an example.

Annex 3

BRAKING TESTS AND PERFORMANCE OF BRAKING SYSTEMS

1. BRAKING TESTS

1.1. General

1.1.1. The performance prescribed for braking systems is based on the stopping distance and the mean fully developed deceleration. The performance of a braking system shall be determined by measuring the stopping distance in relation to the initial speed of the vehicle and/or by measuring the mean fully developed deceleration during the test.

1.1.2. The stopping distance shall be the distance covered by the vehicle from the moment when the driver begins to actuate the control of the braking system until the moment when the vehicle stops; the initial speed shall be the speed at the moment when the driver begins to actuate the control of the braking system; the initial speed shall not be less than 98 per cent of the prescribed speed for the test in question.

The mean fully developed deceleration (d_m) shall be calculated as the deceleration averaged with respect to distance over the interval v_b to v_e , according to the following formula:

$$d_m = \frac{v_b^2 - v_e^2}{25.92\,(s_e - s_b)}$$

where:

v_o = initial vehicle speed in km/h,
v_b = vehicle speed at 0.8 v_o in km/h,
v_e = vehicle speed at 0.1 v_o in km/h,
s_b = distance travelled between v_o and v_b in metres,
s_e = distance travelled between v_o and v_e in metres.

The speed and distance shall be determined using instrumentation having an accuracy of ± 1 per cent at the prescribed speed for the test. The d_m may be determined by other methods than the measurement of speed and distance; in this case, the accuracy of the d_m shall be within ± 3 per cent.

1.2. For the approval of any vehicle, the braking performance shall be measured during road tests conducted in the following conditions:

1.2.1. the vehicle's condition as regards mass must be as prescribed for each type of test and be specified in the test report;

1.2.2. the test must be carried out at the speeds prescribed for each type of test; if the maximum design speed of a vehicle is lower than the speed prescribed for a test, the test shall be performed at the vehicle's maximum speed;

1.2.3. during the tests, the force applied to the brake control in order to obtain the prescribed performance must not exceed the maximum force laid down;

1.2.4. the road must have a surface affording good adhesion, unless specified otherwise in the relevant annexes;

1.2.5. the tests must be performed when there is no wind liable to affect the results;

1.2.6. at the start of the tests, the tyres must be cold and at the pressure prescribed for the load actually borne by the wheels when the vehicle is stationary;

1.2.7. The prescribed performance must be obtained without locking of the wheels at speeds exceeding 15 km/h, without deviation of the vehicle from a 3.5 m wide lane, without exceeding a yaw angle of 15° and without abnormal vibrations.

1.2.8. for electric vehicles with motor(s) permanently connected to the wheels all tests will be carried out with the motor(s) connected;

1.2.9. for electric vehicles as described in paragraph 1.2.8., fitted with an electric regenerative braking system of category A, behaviour tests defined in paragraph 1.4.3.1. of this annex shall be carried out on a track with a low adhesion coefficient (as defined in paragraph 5.2.2. of annex 6);

1.2.9.1. moreover, for vehicles fitted with an electric regenerative braking system of category A, transient conditions as gear changes or accelerator control release must not affect the behaviour of the vehicle in condition described in paragraph 1.2.9.;

1.2.10. in the tests provided in paragraphs 1.2.9. and 1.2.9.1. wheel locking is not allowed. However, steering correction is permitted if the angular rotation of the steering control is within 120° during the initial 2 seconds and not more than 240° in all.

1.3. Behaviour of the vehicle during braking

1.3.1. In braking tests, and in particular in those at high speed, the general behaviour of the vehicle during braking must be checked.

1.3.2. The behaviour of the vehicle on a road on which adhesion is reduced must meet the requirements of annex 5 to this Regulation.

1.4. Type-0 test (ordinary performance test with cold brakes)

1.4.1. General

1.4.1.1. The average temperature of the service brakes on the hottest axle of the vehicle, measured inside the brake linings or on the braking path of the disc or drum, is between 65 and 100°C prior to any brake application.

1.4.1.2. The test must be conducted in the following conditions:

1.4.1.2.1. the vehicle must be laden, the distribution of its mass among the axles being that stated by the manufacturer; where provision is made for several arrangements of the load on the axles the distribution of the maximum mass among the axles must be such that the mass on each axle is proportional to the maximum permissible mass for each axle;

1.4.1.2.2. every test must be repeated on the unladen vehicle; there may be, in addition to the driver, a second person on the front seat who is responsible for noting the results of the test;

1.4.1.2.3. the limits prescribed for minimum performance, both for tests with the vehicle unladen and for tests with the vehicle laden, shall be those laid down hereunder; the vehicle must satisfy both the prescribed stopping distance and the prescribed mean fully developed deceleration, but it may not be necessary to actually measure both parameters;

1.4.1.2.4. the road must be level; unless otherwise specified each test may comprise up to six stops including any needed for familiarization.

1.4.2. Type-0 test with engine disconnected, service braking in accordance with paragraph 2.1.1.(A) of this annex.

The test must be carried out at the speed prescribed, the figures prescribed in this connection being subject to a certain margin of tolerance. The minimum performance prescribed must be attained.

1.4.3. Type-0 test with engine connected, service braking in accordance with paragraph 2.1.1.(B) of this annex.

1.4.3.1. The test shall be carried out with the engine connected, from the speed prescribed in paragraph 2.1.1. (B) of this annex. The minimum performance prescribed shall be attained. This test is not run if the maximum speed of the vehicle is ≤ 125 km/h.

1.4.3.2. In addition, if the maximum speed of the vehicle is greater than 200 km/h, a test is carried out at 80 per cent of the maximum speed of the vehicle. The maximum practical performance figures shall be measured, and the behaviour of the vehicle shall be in accordance with paragraph 1.3.2. of this annex.

1.5. Type-I test (fade and recovery test)

1.5.1. Heating procedure

1.5.1.1. The service brakes of all vehicles must be tested by successively applying and releasing the brakes a number of times, the vehicle being laden, in the conditions shown in the table below:

Conditions			
v_1 (km/h)	v_2 (km/h)	Δt (sec)	n
80% v_{max} ≤ 120	1/2 v_1	45	15

where:

v_1 = initial speed, at beginning of braking
v_2 = speed at end of braking
v_{max} = maximum speed of the vehicle
n = number of brake applications
Δt = duration of a braking cycle: time elapsing between the initiation of one brake application and the initiation of the next.

1.5.1.2. If the characteristics of the vehicle make it impossible to abide by the duration prescribed for Δt, the duration may be increased; in any event, in addition to the time necessary for braking and accelerating the vehicle, a period of 10 seconds must be allowed in each cycle for stabilizing the speed v_1 .

1.5.1.3. In these tests, the force applied to the control must be so adjusted as to attain a mean deceleration of 3 m/s^2 during every brake application; two preliminary tests may be carried out to determine the appropriate control force.

1.5.1.4. During brake applications, the highest gear ratio (excluding overdrive, etc.) must be continuously engaged.

1.5.1.5. For regaining speed after braking, the gearbox must be used in such a way as to attain the speed v_1 in the shortest possible time (maximum acceleration allowed by the engine and gearbox).

1.5.1.6. For electric vehicles not having a sufficient autonomy to carry out the cycles of heating, the tests shall be carried out by respecting speed during the first braking application then by using the maximum acceleration of the vehicle, and brake successively at the speed reached at the end of each 45 seconds cycle duration.

1.5.2. Hot performance

1.5.2.1. At the end of the Type-I test (described in paragraph 1.5.1. of this annex) the hot performance of the service braking system must be measured in the same conditions (and in particular at a mean control force no greater than the mean force actually used) as for the Type-0 test with the engine disconnected (the temperature conditions may be different).

1.5.2.2. This hot performance must not be less than 75 1/ per cent of that prescribed, nor less than 60 per cent of the figure recorded in the Type-0 test with the engine disconnected.

1.5.2.3. For electric vehicles fitted with an electric regenerative braking system of category A, during brake applications, the highest gear must be continuously engaged and the separate electric braking control, if any, not used.

1.5.2.4. In the case of a vehicle which satisfies the 60 per cent requirement specified in paragraph 1.5.2.2. of this annex, but which cannot comply with the 75 1/ per cent requirement of paragraph 1.5.2.2. of this annex, a further hot performance test may be carried out using a control force not exceeding that specified in paragraph 2 of this annex. The results of both tests shall be entered in the report.

1.5.2.5. In the case of the electric vehicles having carried out the cycles of heating, according to paragraph 1.5.1.6. of the present annex, the performance tests shall be carried out at the maximum possible speed by the vehicle at the end of the cycles of heating. For comparison, the performance of the Type-0, brakes cold, will be repeated at this same speed after reconditioning of the linings.

1/ This corresponds to a stopping distance of $0.1\ v + 0.0080\ v^2$ and a mean fully developed deceleration of $4.82\ m/s^2$.

1.5.3. Recovery procedure

Immediately after the hot performance test, make four stops from 50 km/h with the engine connected, at a mean deceleration of 3 m/s^2. Allow an interval of 1.5 km between the start of successive stops. Immediately after each stop, accelerate at maximum rate to 50 km/h and maintain that speed until making the next stop.

1.5.4. Recovery performance

At the end of the recovery procedure, the recovery performance of the service braking system must be measured in the same conditions as for the Type-0 test with the engine disconnected (the temperature conditions may be different), using a mean force on the control, which is not more than the mean control force used in the corresponding Type-0 test.

This recovery performance must not be less than 70 per cent, nor more than 150 per cent, of the figure recorded in the Type-0 test with the engine disconnected.

2. PERFORMANCE OF BRAKING SYSTEMS

2.1. Service braking system

2.1.1. The service brakes shall be tested under the conditions shown in the following table:

(A)	Type-0 test with engine disconnected	v	100 km/h
		s ≤	$0.1v + \frac{0.0060}{} v^2$ (m)
		d_m ≥	6.43 m/s^2
(B)	Type-0 test with engine connected	v	80% v_{max} ≤ 160 km/h
		s ≤	$0.1v + \frac{0.0067}{} v^2$ (m)
		d_m ≥	5.76 m/s^2
		f	6.5 - 50 daN

where:

v	=	test speed, in km/h
s	=	stopping distance, in metres
d_m	=	mean fully developed deceleration, in m/s^2
f	=	force applied to foot control, in daN
v_{max}	=	maximum speed of the vehicle, in km/h

2.1.2. In the case of a motor vehicle authorized to tow an unbraked trailer, the minimum performance prescribed for the corresponding motor vehicle for the Type-0 test with engine disconnected must be attained with the unbraked trailer coupled to the motor vehicle and with the unbraked trailer laden to the maximum mass declared by the motor vehicle manufacturer. However, the minimum combination performance shall be not less than 5.4 m/s^2 both in laden and unladen conditions.
The combination performance shall be verified by calculations referring to the maximum braking performance actually achieved by the motor vehicle alone (laden) during the Type-0 test with the engine disconnected, using the following formula (no practical tests with a coupled unbraked trailer are required):

$$d_{M+R} = d_M \cdot \frac{PM}{PM + PR}$$

where:

d_{M+R}	=	calculated mean fully developed deceleration of the motor vehicle when coupled to an unbraked trailer, in m/s^2
d_M	=	maximum mean fully developed deceleration of the motor vehicle alone achieved during the Type-0 test with engine disconnected, in m/s^2
PM	=	mass of the motor vehicle (laden)
PR	=	maximum mass of an unbraked trailer which may be coupled, as declared by the motor vehicle manufacturer.

2.2. Secondary braking system

2.2.1. The performance of the secondary braking system shall be tested by the Type-0 test with the engine disconnected from an initial vehicle speed of 100 km/h and a force applied to the service brake control not less than 6.5 daN and not exceeding 50 daN.

2.2.2. The secondary braking system must give a stopping distance not exceeding the following value:

$$0.1\ v + 0.0158\ v^2 \text{ (m)}$$

and a mean fully developed deceleration not less than 2.44 m/s^2 (corresponding to the second term of the above formula).

2.2.3. The secondary braking effectiveness test shall be conducted by simulating the actual failure conditions in the service braking system.

2.2.4. For the electric vehicles, the performances for two following additional failures will be checked:

2.2.4.1. For a total failure of the electric component of the service brake;

2.2.4.2. In the case where the electric component delivers the maximum braking force where a failure of the electric transmission occurs.

2.3. Parking braking system

2.3.1. The parking braking system must be capable of holding the laden vehicle stationary on a 20 per cent up or down gradient.

2.3.2. On vehicles to which the coupling of a trailer is authorized, the parking braking system of the motor vehicle must be capable of holding the combination of vehicles stationary on a 12 per cent up or down gradient.

2.3.3. If the control device is manual, the force applied to it must not exceed 40 daN.

2.3.4. If it is a foot control device, the force exerted on the control must not exceed 50 daN.

2.3.5. A parking braking system which has to be actuated several times before it attains the prescribed performance is admissible.

2.3.6. To check compliance with the requirement specified in paragraph 5.2.2.4. of this Regulation, a Type-0 test must be carried out, with the engine disconnected, at an initial test speed of 30 km/h. The mean fully developed deceleration on application of the control of the parking brake system and the deceleration immediately before the vehicle stops, shall not be less than 1.5 m/s^2. The test shall be carried out with the laden vehicle. The force exerted on the braking control device shall not exceed the specified values.

3. RESPONSE TIME

3.1. Where a vehicle is equipped with a service braking system which is totally or partially dependent on a source of energy other than the muscular effort of the driver, the following requirements must be satisfied:

3.1.1. in an emergency manoeuvre, the time elapsing between the moment when the control device begins to be actuated and the moment when the braking force on the least favourable placed axle reaches the level corresponding to the prescribed performance must not exceed 0.6 seconds;

3.1.2. in the case of vehicles fitted with hydraulic braking systems, the requirements of paragraph 3.1.1. above are considered to be satisfied if, in an emergency manoeuvre, the deceleration of the vehicle or the pressure at the least favourable brake cylinder, reaches a level corresponding to the prescribed performance within 0.6 seconds.

Annex 4

PROVISIONS RELATING TO ENERGY SOURCES AND ENERGY STORAGE DEVICES (ENERGY ACCUMULATORS)

HYDRAULIC BRAKING SYSTEMS WITH STORED ENERGY

1. CAPACITY OF ENERGY STORAGE DEVICES (ENERGY ACCUMULATORS)

1.1. General

1.1.1. Vehicles on which the braking equipment requires the use of stored energy provided by hydraulic fluid under pressure shall be equipped with energy storage devices (energy accumulators) of a capacity meeting the requirements of paragraphs 1.2. or 1.3. of this annex;

1.1.2. However, the energy storage devices shall not be required to be of a prescribed capacity if the braking system is such that in the absence of any energy reserve it is possible with the service brake control to achieve a braking performance at least equal to that prescribed for the secondary braking system;

1.1.3. In verifying compliance with the requirements of paragraphs 1.2., 1.3. and 2.1. of this annex, the brakes shall be adjusted as closely as possible and, for paragraph 1.2. of this annex, the rate of full-stroke actuations must be such as to provide an interval of at least 60 seconds between each actuation.

1.2. Vehicles equipped with a hydraulic braking system with stored energy shall meet the following requirements:

1.2.1. After eight full-stroke actuations of the service brake control, it shall still be possible to achieve, on the ninth application, the performance prescribed for the secondary braking system.

1.2.2. Testing shall be performed in conformity with the following requirements:

1.2.2.1. Testing shall commence at a pressure that may be specified by the manufacturer but is not higher than the cut-in pressure; 1/.

1.2.2.2. The energy storage device(s) shall not be fed; in addition, any energy storage device(s) for auxiliary equipment shall be isolated.

1/ The initial energy level shall be stated in the approval document.

1.3. Vehicles equipped with a hydraulic braking system with stored energy which cannot meet the requirements of paragraph 5.2.4.1. of this Regulation shall be deemed to satisfy that paragraph if the following requirements are met:

1.3.1. After any single transmission failure it shall still be possible after eight full-stroke actuations of the service brake control, to achieve, at the ninth application, at least the performance prescribed for the secondary braking system.

1.3.2. Testing shall be performed in conformity with the following requirements:

1.3.2.1. With the energy source stationary or operating at a speed corresponding to the engine idling speed, any transmission failure may be induced. Before inducing such a failure, the energy storage device(s) shall be at a pressure that may be specified by the manufacturer but not exceeding the cut-in pressure;

1.3.2.2. The auxiliary equipment and its energy storage devices, if any, shall be isolated.

2. CAPACITY OF HYDRAULIC FLUID ENERGY SOURCES

2.1. The energy sources shall meet the requirements set out in the following paragraphs.

2.1.1. Definitions

2.1.1.1. "p_1" represents the maximum system operational pressure (cut-out pressure) in the energy storage device(s) specified by the manufacturer.

2.1.1.2. "p_2" represents the pressure after four full-stroke actuations with the service brake control, starting at p_1, without having fed the energy storage device(s).

2.1.1.3. "t" represents the time required for the pressure to rise from p_2 to p_1 in the energy storage device(s) without application of the brake control.

2.1.2. Conditions of measurement

2.1.2.1. During the tests to determine the time t, the feed rate of the energy source shall be that obtained when the engine is running at the speed corresponding to its maximum power or at the speed allowed by the over-speed governor.

2.1.2.2. During the test to determine the time t, energy storage device(s) for auxiliary equipment shall not be isolated other than automatically.

2.1.3. Interpretation of results

2.1.3.1. In the case of all vehicles, the time t shall not exceed 20 seconds.

3. CHARACTERISTICS OF WARNING DEVICES

With the engine stationary and commencing at a pressure that may be specified by the manufacturer but does not exceed the cut-in pressure, the warning device shall not operate following two full-stroke actuations of the service brake control.

Annex 5

DISTRIBUTION OF BRAKING AMONG THE AXLES OF VEHICLES

1. GENERAL

Vehicles which are not equipped with an anti-lock system as defined in annex 6 to this Regulation shall meet all the requirements of this annex. If a special device is used, this must operate automatically.

2. SYMBOLS

i	=	axle index (i = 1, front axle; i = 2, rear axle)
P_i	=	normal reaction of road surface on axle i under static conditions
N_i	=	normal reaction of road surface on axle i under braking
T_i	=	force exerted by the brakes on axle i under normal braking conditions on the road
f_i	=	T_i/N_i , adhesion utilized by axle i 1/
J	=	deceleration of the vehicle
g	=	acceleration due to gravity : $g = 10\ m/s^2$
z	=	braking rate of vehicle = J/g
P	=	mass of vehicle
h	=	height of centre of gravity specified by the manufacturer and agreed by the Technical Services conducting the approval test
E	=	wheelbase
k	=	theoretical coefficient of adhesion between tyre and road

---

1/ "Adhesion utilisation curves" of a vehicle means curves showing, for specified load conditions, the adhesion utilized by each axle i plotted against the braking rate of the vehicle.

3. REQUIREMENTS

3.1.(A) For all states of load of the vehicle, the adhesion utilization curve of the front axle shall be situated above that for the rear axle: 2/
for all braking rates between 0.15 and 0.8 $m/^2$:

3.1.(B) For k values between 0.2 and 0.8: 2/
$z \geq 0.1 + 0.7 (k - 0.2)$ (see diagram 1 of this annex)

3.2. In order to verify the requirements of paragraph 3.1. of this annex, the manufacturer shall provide the adhesion utilization curves for the front and rear axles calculated by the formulae:

$$f_1 = \frac{T_1}{N_1} = \frac{T_1}{P_1 + z \cdot \frac{h}{E} \cdot P \cdot g}$$

$$f_2 = \frac{T_2}{N_2} = \frac{T_2}{P_2 - z \cdot \frac{h}{E} \cdot P \cdot g}$$

The curves shall be plotted for both the following load conditions:

3.2.1. unladen, in running order with the driver on board;

3.2.2. laden; where provision is made for several possibilities of load distribution, the one whereby the front axle is the most heavily laden shall be the one considered;

3.2.3. for electric vehicles fitted with an electric regenerative braking system of category B, where the electric regenerative braking capacity is influenced by the electric state of charge, the curves shall be plotted by taking account of the electric braking component under the minimal and maximum conditions of delivered braking force. This requirement is not applicable if the vehicle is equipped with an anti-lock device which controls the wheels connected to the electric braking then the requirements of annex 6 to this Regulation shall apply.

2/ The provisions of paragraph 3.1. do not affect the requirements of annex 3 to this Regulation relating to the braking performance. However, if, in tests made under the provisions of paragraph 3.1., braking performances are obtained which are higher than those prescribed in annex 3, the provisions relating to the adhesion utilization curves shall be applied within the areas of diagram 1 of this annex defined by the straight lines k = 0.8 and z = 0.8.

4. REQUIREMENTS TO BE MET IN CASE OF FAILURE OF THE BRAKING DISTRIBUTION SYSTEM

When the requirements of this annex are fulfilled by means of a special device (e.g. controlled mechanically by the suspension of the vehicle), it shall be possible, in the event of the failure of its control, (e.g. by disconnecting the control linkage), to stop the vehicle under the conditions of the Type-0 test with the engine disconnected to give a stopping distance not exceeding $0.1\ v + 0.0100\ v^2$ (m) and a mean fully developed deceleration not less than $3.86\ m/s^2$.

5. VEHICLE TESTING

During the type-approval testing of a vehicle, the technical inspection authority shall verify conformity with the requirements contained in the present annex, by carrying out the following tests:

5.1. wheel - lock sequence test (see appendix 1)

If the wheel-lock sequence test confirms that the front wheels lock before or simultaneously with the rear wheels, conformity with paragraph 3. of this annex has been verified and testing is complete.

5.2. Additional tests

If the wheel-lock sequence test indicates that the rear wheels lock before the front wheels, then the vehicle:

(a) will be subjected to additional testing, as follows:

(i) additional wheel-lock sequence tests; and/or

(ii) torque wheel tests (see appendix 2) to determine brake factors to generate adhesion utilization curves; these curves must satisfy the requirements in paragraph 3.1.(A) of this annex.

(b) may be refused type-approval.

5.3. The results of the practical tests shall be appended to the type-approval report.

6. CONFORMITY OF PRODUCTION

6.1. When checking vehicles for conformity of production, the Technical Services should follow the same procedures as for type-approval.

6.2. The requirements shall also be the same as for type-approval, except that in the test described in paragraph 5.2.(a)(ii) of this annex, the rear axle curve must lie below the line z = 0.9 k for all braking rates between 0.15 and 0.8 (instead of meeting the requirement in paragraph 3.1.(A) (see diagram 2).

DIAGRAM 1

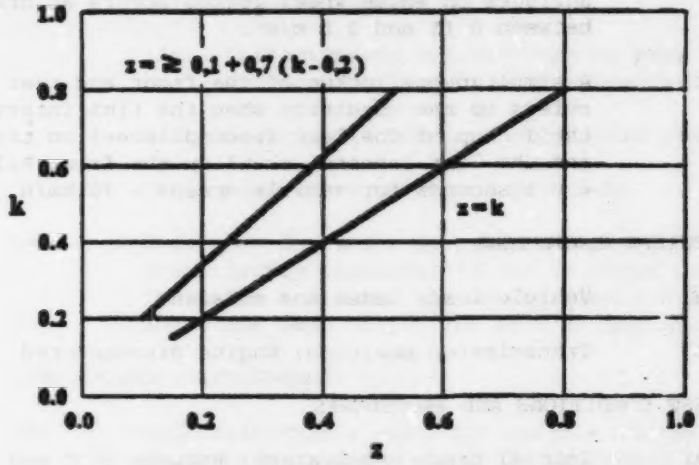
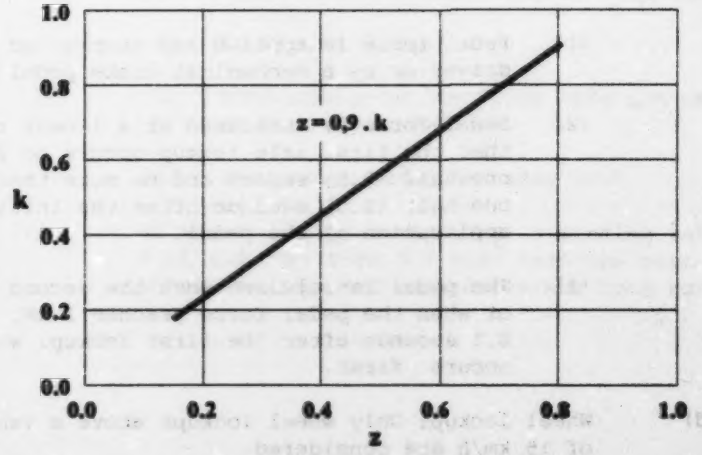


DIAGRAM 2



Annex 5 - Appendix 1

WHEEL-LOCK SEQUENCE TEST PROCEDURE

1. GENERAL INFORMATION

(a) The purpose of this test is to ensure that lockup of both front wheels occurs at a lower deceleration rate than the lockup of both rear wheels when tested on road surfaces on which wheel lockup occurs at braking rates between 0.15 and 0.8 m/s^2.

(b) A simultaneous lockup of the front and rear wheels refers to the condition when the time interval between the lockup of the last (second) wheel on the rear axle and the last (second) wheel on the front axle is < 0.1 seconds for vehicle speeds > 30 km/h.

2. VEHICLE CONDITIONS

(a) Vehicle load: Laden and unladen

(b) Transmission position: Engine disconnected

3. TEST CONDITIONS AND PROCEDURES

(a) Initial brake temperature: Between 65°C and 100°C average on the hottest axle.

(b) Test speed: 65 km/h for a braking rate ≤ 0.50 ;
100 km/h for a braking rate > 0.50.

(c) Pedal force:

(1) Pedal force is applied and controlled by a skilled driver or by a mechanical brake pedal actuator.

(2) Pedal force is increased at a linear rate such that the first axle lockup occurs no less than one-half (0.5) second and no more than one and one-half (1.5) seconds after the initial application of the pedal.

(3) The pedal is released when the second axle locks, or when the pedal force reaches 1 kN, or 0.1 seconds after the first lockup, whichever occurs first.

(d) Wheel lockup: Only wheel lockups above a vehicle speed of 15 km/h are considered.

(e) Test surface: This test is conducted on road test surfaces on which wheel lockup occurs at braking rates between 0.15 and 0.8 m/s^2.

(f) Data to be recorded: The following information must be automatically recorded in phase continuously throughout each test run such that values of the variables can be cross referenced in real time:

(1) Vehicle speed;

(2) Instantaneous vehicle braking rate (e.g. by differentiation of vehicle speed);

(3) Brake pedal force (or hydraulic line pressure);

(4) Angular velocity at each wheel.

(g) Each test run shall be repeated once to confirm the wheel lockup sequence: if one of these two results indicates a failure to comply, then a third test run under the same conditions will be decisive.

4. PERFORMANCE REQUIREMENTS

(a) Both rear wheels shall not reach a locked condition prior to both front wheels being locked - at vehicle braking rates between 0.15 and 0.8 m/s^2.

(b) If, when tested to the procedure specified above, and at vehicle braking rates between 0.15 and 0.8 m/s^2 the vehicle meets one of the following criteria, then it passes this wheel lockup sequence requirement:

(1) No wheels lock;

(2) Both wheels on the front axle and one or no wheels on the rear axle lock;

(3) Both axles simultaneously lock.

(c) If wheel lockup commences at a braking rate less than 0.15 and more than 0.8 m/s^2 then the test is invalid and should be repeated on a different road surface.

(d) If, either laden or unladen, at a braking rate between 0.15 and 0.8 m/s^2 both wheels on the rear axle and one or no wheels on the front axle lock, then it fails the wheel lockup sequence test. In this latter case, the vehicle must be submitted to the 'torque wheels' test procedure to determine the objective brake factors for calculation of the adhesion utilization curves.

Annex 5 - Appendix 2

TORQUE WHEEL TEST PROCEDURE

1. GENERAL INFORMATION

The purpose of this test is to measure the brake factors and thus determine the adhesion utilization of the front and rear axles over a range of braking rates between 0.15 and 0.8.

2. VEHICLE CONDITIONS

(a) Vehicle load: Laden and unladen

(b) Transmission position: Engine disconnected

3. TEST CONDITIONS AND PROCEDURES

(a) Initial brake temperature: Between 65°C and 100°C average on the hottest axle.

(b) Test speeds: 100 km/h and 50 km/h.

(c) Pedal force: Pedal force is increased at a linear rate between 100 and 150 N/sec for the 100 km/h test speed, or between 100 and 200 N/sec for the 50 km/h test speed, until the first axle locks or until a pedal force of 1 kN is reached, whichever occurs first.

(d) Brake cooling: Between brake applications, the vehicle is driven at speeds up to 100 km/h until the initial brake temperature specified in paragraph 3.(a) above is reached.

(e) Number of runs: With the vehicle unladen, run five stops from a speed of 100 km/h and five stops from a speed of 50 km/h, while alternating between the two test speeds after each stop. With the vehicle laden, repeat the five stops at each test speed while alternating between the two test speeds.

(f) Test surface: This test is conducted on a road test surface affording good adhesion.

(g) Data to be recorded: The following information must be automatically recorded in phase continuously throughout each test run such that values of the variables can be cross referenced in real time:

(1) Vehicle speed
(2) Brake pedal force
(3) Angular velocity of each wheel
(4) Brake torque at each wheel
(5) Hydraulic line pressure in each brake circuit, including transducers on at least one front wheel and one rear wheel downstream of any operative proportioning or pressure limiting valve(s)
(6) Vehicle deceleration.

(h) Sample rate: All data acquisition and recording equipment shall support a minimum sample rate of 40 Hz on all channels.

(i) Determination of front versus rear brake pressure: Determine the front versus rear brake pressure relationship over the entire range of line pressures. Unless the vehicle has a variable brake proportioning system, this determination is made by static tests. If the vehicle has a variable brake proportioning system, dynamic tests are run with the vehicle both laden and unladen. Fifteen snubs from 50 km/h are made for each of the two load conditions, using the same initial conditions specified in this appendix.

4. DATA REDUCTION

(a) The data from each brake application prescribed in paragraph 3.(e) above is filtered using a five-point, on-centre moving average for each data channel.

(b) For each brake application prescribed in paragraph 3.(e) above, determine the slope (brake factor) and pressure axis intercept (brake hold-off pressure) of the linear least squares equation best describing the measured torque output at each braked wheel as a function of measured line pressure applied at the same wheel. Only torque output values obtained from data collected when the vehicle deceleration is within the range of 0.15 g to 0.80 g are used in the regression analysis.

(c) Average the results of paragraph (b) above to calculate the average brake factor and brake hold-off pressure for all brake applications for the front axle.

(d) Average the results of paragraph (b) above to calculate the average brake factor and brake hold-off pressure for all brake applications for the rear axle.

(e) Using the relationship between front and rear brake line pressure determined in paragraph 3.(i) above and the dynamic tyre rolling radius, calculate the braking force at each axle as a function of front brake line pressure.

(f) Calculate the braking rate of the vehicle as a function of the front brake line pressure using the following equation:

$$z = \frac{T_1 + T_2}{P \cdot g}$$

where z = braking rate at a given front brake line pressure

T_1 , T_2 = braking forces at the front and rear axles respectively, corresponding to the same front brake line pressure

P = vehicle mass

(g) Calculate the adhesion utilized at each axle as a function of braking rate using the following formulae:

$$f_1 = \frac{T_1}{P_1 + \frac{z \cdot h \cdot P \cdot g}{E}}$$

$$f_2 = \frac{T_2}{P_2 - \frac{z \cdot h \cdot P \cdot g}{E}}$$

The symbols are defined in paragraph 2. of this annex.

(h) Plot f_1 and f_2 as a function of z, for both laden and unladen load conditions. These are the adhesion utilization curves for the vehicle, which must satisfy the requirements in paragraph 5.2.(a)(ii) of this annex (or, in the case of Conformity of Production checks, these curves must satisfy the requirements in paragraph 6.2. of this annex).

Annex 6

TEST REQUIREMENTS FOR VEHICLES FITTED WITH ANTI-LOCK SYSTEMS

1. GENERAL

1.1. This annex defines the required braking performance for road vehicles fitted with anti-lock systems.

1.2. The anti-lock systems known at present comprise a sensor or sensors, a controller or controllers and a modulator or modulators. Any device of a different design which may be introduced in the future, or where an anti-lock braking function is integrated into another system, shall be deemed to be an anti-lock braking system within the meaning of this annex and annex 5 to this Regulation, if it provides performance equal to that prescribed by this annex.

2. DEFINITIONS

2.1. An "anti-lock system" is a part of a service braking system which automatically controls the degree of slip, in the direction of rotation of the wheel(s), on one or more wheels of the vehicle during braking.

2.2. "Sensor" means a component designed to identify and transmit to the controller the conditions of rotation of the wheel(s) or the dynamic conditions of the vehicle.

2.3. "Controller" means a component designed to evaluate the data transmitted by the sensor(s) and to transmit a signal to the modulator.

2.4. "Modulator" means a component designed to vary the braking force(s) in accordance with the signal received from the controller.

2.5. "Directly controlled wheel" means a wheel whose braking force is modulated according to data provided at least by its own sensor. 1/

2.6. "Indirectly controlled wheel" means a wheel whose braking force is modulated according to data provided by the sensor(s) of other wheel(s). 1/

All footnotes to annex 6 can be found at the end of this annex.

2.7. "Full cycling" means that the anti-lock system is repeatedly modulating the brake force to prevent the directly controlled wheels from locking. Brake applications where modulation only occurs once during the stop shall not be considered to meet this definition.

3. TYPES OF ANTI-LOCK SYSTEMS

3.1. A vehicle is deemed to be equipped with an anti-lock system within the meaning of paragraph 1. of annex 5 to this Regulation, if one of the following systems is fitted:

3.1.1. Category 1 anti-lock system

A vehicle equipped with a category 1 anti-lock system shall meet all the requirements of this annex.

3.1.2. Category 2 anti-lock system

A vehicle equipped with a category 2 anti-lock system shall meet all the requirements of this annex, except those of paragraph 5.3.5.

3.1.3. Category 3 anti-lock system

A vehicle equipped with a category 3 anti-lock system shall meet all the requirements of this annex, except those of paragraphs 5.3.4. and 5.3.5. On such vehicles, any individual axle which does not include at least one directly controlled wheel must fulfil the conditions of adhesion utilization and the wheel-locking sequence of annex 5 to this Regulation, instead of the adhesion utilization requirements prescribed in paragraph 5.2. of this annex. However, if the relative positions of the adhesion utilization curves do not meet the requirements of paragraph 3.1. of annex 5 to this Regulation, a check shall be made to ensure that the wheels on at least one of the rear axles do not lock before those of the front axle or axles under the conditions prescribed in paragraph 3.1. of annex 5 to this Regulation, with regard to the braking rate and the load respectively. These requirements may be checked on high- and low-adhesion road surfaces (about 0.8 and 0.3 maximum) by modulating the service braking control force.

All footnotes to annex 6 can be found at the end of this annex.

4. GENERAL REQUIREMENTS

4.1. Any electrical failure or sensor anomaly that affects the system with respect to the functional and performance requirements in this annex, including those in the supply of electricity, the external wiring to the controller(s), the controller(s) 2/ and the modulator(s) shall be signalled to the driver by a specific optical warning signal. The yellow warning signal specified in paragraph 5.2.21.1.2. of this Regulation shall be used for this purpose.

4.1.1. The warning signal shall light up when the anti-lock system is energized and with the vehicle stationary it shall be verified that none of the above-mentioned defects are present before extinguishing the signal.

4.1.2. The static sensor check may verify that a sensor was not functioning the last time that the vehicle was at a speed greater than 10 km/h. 3/ Also during this verification phase, the electrically controlled pneumatic modulator valve(s) shall cycle at least once.

4.1.3. The above-mentioned optical warning signal must be visible even in daylight and it must be easy for the driver to check that it is in working order.

4.2. In the event of a single electrical functional failure which only affects the anti-lock function, as indicated by the above-mentioned yellow warning signal, the subsequent service braking performance must not be less than 80 per cent of the prescribed performance according to the Type-0 test with the engine disconnected. This corresponds to a stopping distance of $0.1\ v + 0.0075\ v^2$ (m) and a mean fully developed deceleration of $5.15\ m/s^2$.

4.3. The operation of the anti-lock system must not be adversely affected by magnetic or electrical fields. 4/ (This shall be demonstrated by compliance with Regulation No. 10, 02 series of amendments).

4.4. A manual device may not be provided to disconnect or change the control mode 5/ of the anti-lock system.

All footnotes to annex 6 can be found at the end of this annex.

5. SPECIAL PROVISIONS

5.1. Energy consumption

Vehicles equipped with anti-lock systems must maintain their performance when the service braking control device is fully applied for long periods. Compliance with this requirement shall be verified by means of the following tests:

5.1.1. Test procedure

5.1.1.1. The initial energy level in the energy storage device(s) shall be that specified by the manufacturer. This level shall be at least such as to ensure the efficiency prescribed for service braking when the vehicle is laden. The energy storage device(s) for pneumatic auxiliary equipment must be isolated.

5.1.1.2. From an initial speed of not less than 50 km/h, on a surface with a coefficient of adhesion of 0.3 6/ or less, the brakes of the laden vehicle shall be fully applied for a time t , during which time the energy consumed by the indirectly controlled wheels shall be taken into consideration and all directly controlled wheels must remain under control of the anti-lock system.

5.1.1.3. The vehicle's engine shall then be stopped or the supply to the energy transmission storage device(s) cut off.

5.1.1.4. The service braking control shall then be fully actuated four times in succession with the vehicle stationary.

5.1.1.5. When the brakes are applied for the fifth time, it must be possible to brake the vehicle with at least the performance prescribed for secondary braking of the laden vehicle.

5.1.2. Additional requirements

5.1.2.1. The coefficient of adhesion of the road surface shall be measured with the vehicle under test, by the method described in paragraph 1.1. of appendix 2 to this annex.

5.1.2.2. The braking test shall be conducted with the engine disconnected and idling, and with the vehicle laden.

All footnotes to annex 6 can be found at the end of this annex.

5.1.2.3. The braking time t shall be determined by the formula:

$$t = \frac{v_{max}}{7}$$

(but not less than 15 seconds)

where t is expressed in seconds and v_{max} represents the maximum design speed of the vehicle expressed in km/h, with an upper limit of 160 km/h.

5.1.2.4. If the time t cannot be completed in a single braking phase, further phases may be used, up to a maximum of four in all.

5.1.2.5. If the test is conducted in several phases, no fresh energy shall be supplied between the phases of the test.
From the second phase, the energy consumption corresponding to the initial brake application may be taken into account, by subtracting one full brake application from the four full applications prescribed in paragraph 5.1.1.4. (and 5.1.1.5. and 5.1.2.6.) of this annex for each of the second, third and fourth phases used in the test prescribed in paragraph 5.1.1. of this annex as applicable.

5.1.2.6. The performance prescribed in paragraph 5.1.1.5. of this annex shall be deemed to be satisfied if, at the end of the fourth application, with the vehicle stationary, the energy level in the storage device(s) is at or above that required for secondary braking with the laden vehicle.

5.2. Utilization of adhesion

5.2.1. The utilization of adhesion by the anti-lock system takes into account the actual increase in braking distance beyond the theoretical minimum. The anti-lock system shall be deemed to be satisfactory when the condition $\varepsilon \geq 0.75$ is satisfied, where ε represents the adhesion utilized, as defined in paragraph 1.2. of appendix 2 to this annex.

5.2.2. The adhesion utilization ε shall be measured on road surfaces with a coefficient of adhesion of 0.3 6/ or less, and of about 0.8 (dry road), with an initial speed of 50 km/h. To eliminate the effects of differential brake temperaturers it is recommended that z_{AL} be determined prior to the determination of k.

All footnotes to annex 6 can be found at the end of this annex.

5.2.3. The test procedure to determine the coefficient of adhesion (k) and the formulae for calculation of the adhesion utilization (e) shall be those laid down in appendix 2 to this annex.

5.2.4. The utilization of adhesion by the anti-lock system shall be checked on complete vehicles equipped with anti-lock systems of categories 1 or 2. In the case of vehicles equipped with category 3 anti-lock systems, only the axle(s) with at least one directly controlled wheel must satisfy this requirement.

5.2.5. The condition $e \geq 0.75$ shall be checked with the vehicle laden and unladen.

The laden test on the high adhesion surface may be omitted if the prescribed force on the control device does not achieve full cycling of the anti-lock system.

For the unladen test, the control force may be increased up to 100 daN if no cycling is achieved with its full force value 7/ . If 100 daN is insufficient to make the system cycle, then this test may be omitted.

5.3. Additional checks

The following additional checks shall be carried out with the engine disconnected, with the vehicle laden and unladen:

5.3.1. The wheels directly controlled by an anti-lock system must not lock when the full force 7/ is suddenly applied on the control device, on the road surfaces specified in paragraph 5.2.2. of this annex, at an initial speed of $v = 40$ km/h and at a high initial speed $v = 0.8\ v_{max} \leq 120$ km/h; 8/

5.3.2. When an axle passes from a high-adhesion surface (k_H) to a low-adhesion surface (k_L), where $k_H \geq 0.5$ and $k_H / k_L \geq 2$, 9/ with the full force 7/ applied on the control device, the directly controlled wheels must not lock. The running speed and the instant of applying the brakes shall be so calculated that, with the anti-lock system fully cycling on the high-adhesion surface, the passage from one surface to the other is made at high and at low speed, under the conditions laid down in paragraph 5.3.1.; 8/

5.3.3. When a vehicle passes from a low-adhesion surface (k_L) to a high-adhesion surface (k_H) where $k_H \geq 0.5$ and $k_H / k_L \geq 2$, 9/

All footnotes to annex 6 can be found at the end of this annex.

with the full force 7/ applied on the control device, the deceleration of the vehicle must rise to the appropriate high value within a reasonable time and the vehicle must not deviate from its initial course. The running speed and the instant of applying the brake shall be so calculated that, with the anti-lock system fully cycling on the low-adhesion surface, the passage from one surface to the other occurs at approximately 50 km/h;

5.3.4. The provisions of this paragraph shall only apply to vehicles equipped with anti-lock systems of categories 1 or 2. When the right and left wheels of the vehicle are situated on surfaces with differing coefficients of adhesion (k_H and k_L), where $k_H \geq 0.5$ and $k_H / k_L \geq 2$, 9/ the directly controlled wheels must not lock when the full force 7/ is suddenly applied on the control device at a speed of 50 km/h;

5.3.5. Furthermore, laden vehicles equipped with anti-lock systems of category 1 shall, under the conditions of paragraph 5.3.4. of this annex satisfy the prescribed braking rate in appendix 3 to this annex;

5.3.6. However, in the tests provided in paragraphs 5.3.1., 5.3.2., 5.3.3., 5.3.4. and 5.3.5. of this annex, brief periods of wheel-locking shall be allowed. Furthermore, wheel-locking is permitted when the vehicle speed is less than 15 km/h; likewise, locking of indirectly controlled wheels is permitted at any speed, but stability and steerability must not be affected and the vehicle must not exceed a yaw angle of 15° or deviate from a 3.5 m wide lane;

5.3.7. During the tests provided in paragraphs 5.3.4. and 5.3.5. of this annex, steering correction is permitted, if the angular rotation of the steering control is within 120° during the initial 2 seconds, and not more than 240° in all. Furthermore, at the beginning of these tests the longitudinal median plane of the vehicle must pass over the boundary between the high- and low-adhesion surfaces and during these tests no part of the tyres must cross this boundary.

All footnotes to annex 6 can be found at the end of this annex.

1/ Anti-lock systems with select-high control are deemed to include both directly and indirectly controlled wheels; in systems with select-low control, all sensed wheels are deemed to be directly controlled wheels.

2/ Until uniform test procedures have been agreed, the manufacturer shall provide the Technical Service with an analysis of potential failures within the controller(s) and their effects. This information shall be subject to discussion and agreement between the Technical Service and the vehicle manufacturer.

3/ The warning signal may light up again while the vehicle is stationary, provided that it is extinguished before the vehicle speed reaches 10 km/h when no defect is present.

4/ Until uniform test procedures have been agreed, the manufacturers shall provide the Technical Services with their test procedures and results.

5/ It is understood that devices changing the control mode of the anti-lock system are not subject to paragraph 4.4. if in the changed control mode condition all requirements to the category of anti-lock systems, with which the vehicle is equipped, are fulfilled.

6/ Until such test surfaces become generally available, tyres at the limit of wear, and higher values up to 0.4 may be used at the discretion of the Technical Service. The actual value obtained and the type of tyres and surface shall be recorded.

7/ "Full force" means the maximum force laid down in annex 3 to this Regulation; a higher force may be used if required to activate the anti-lock system.

8/ The purpose of these tests is to check that the wheels do not lock and that the vehicle remains stable; it is not necessary, therefore, to make complete stops and bring the vehicle to a halt on the low-adhesion surface.

9/ k_H is the high-adhesion surface coefficient
k_L is the low-adhesion surface coefficient
k_H and k_L are measured as laid down in appendix 2 to this annex.

Annex 6 - Appendix 1

SYMBOLS AND DEFINITIONS

TABLE: SYMBOLS AND DEFINITIONS

SYMBOL	NOTES
E	wheelbase
ϵ	the adhesion utilized of the vehicle: quotient of the maximum braking rate with the anti-lock system operative (z_{AL}) and the coefficient of adhesion (k)
ϵ_i	the ϵ - value measured on axle i (in the case of a motor vehicle with a category 3 anti-lock system)
ϵ_H	the ϵ - value on the high-adhesion surface
ϵ_L	the ϵ - value on the low-adhesion surface
F	force (N)
F_{dyn}	normal reaction of road surface under dynamic conditions with the anti-lock system operative
F_{idyn}	F_{dyn} on axle i in case of power-driven vehicles
F_i	normal reaction of road surface on axle i under static conditions
F_M	total normal static reaction of road surface on all wheels of power-driven vehicle
F_{Mnd} 1/	total normal static reaction of road surface on the unbraked and non-driven axles of the power-driven vehicle
F_{Md} 1/	total normal static reaction of road surface on the unbraked and driven axles of the power-driven vehicle
F_{MM} 1/	$0.01\ F_{Mnd} + 0.015\ F_{Md}$
g	acceleration due to gravity (9.81 m/s^2)
h	height of centre of gravity specified by the manufacturer and agreed by the Technical Service conducting the approval test
k	coefficient of adhesion between tyre and road
k_f	k-factor of one front axle
k_H	k-value determined on the high-adhesion surface
k_i	k-value determined on axle i for a vehicle with a category 3 anti-lock system

1/ F_{Mnd} and F_{Md} in case of two-axled motor vehicles: these symbols may be simplified to corresponding F_i - symbols.

TABLE: SYMBOLS AND DEFINITIONS (cont'd)

SYMBOL	NOTES
k_L	k-value determined on the low-adhesion surface
k_{lock}	value of adhesion for 100 % slip
k_M	k - factor of the power-driven vehicle
k_{peak}	maximum value of the curve "adhesion versus slip"
k_r	k - factor of one rear axle
P	mass of individual vehicle (kg)
R	ratio of k_{peak} to k_{lock}
t	time interval (s)
t_m	mean value of t
t_{min}	minimum value of t
z	braking rate
z_{AL}	braking rate z of the vehicle with the anti-lock system operative
z_m	mean braking rate
z_{max}	maximum value of z
z_{MALS}	z_{AL} of the power-driven vehicle on a "split surface"

Annex 6 - Appendix 2

UTILIZATION OF ADHESION

1. METHOD OF MEASUREMENT

1.1. Determination of the coefficient of adhesion (k)

1.1.1. The coefficient of adhesion (k) shall be determined as the quotient of the maximum braking forces without locking the wheels and the corresponding dynamic load on the axle being brakes.

1.1.2. The brakes shall be applied on only one axle of the vehicle under test, at an initial speed of 50 km/h. The braking forces shall be distributed between the wheels of the axle to reach maximum performance. The anti-lock system shall be disconnected, or inoperative, between 40 km/h and 20 km/h.

1.1.3. A number of tests at increments of line pressure shall be carried out to determine the maximum braking rate of the vehicle (z_{max}). During each test, a constant input force shall be maintained and the braking rate will be determined by reference to the time taken (t) for the speed to reduce from 40 km/h to 20 km/h using the formula:

$$z = \frac{0.566}{t}$$

z_{max} is the maximum value of z ; t is in seconds.

1.1.3.1. Wheel lock may occur below 20 km/h.

1.1.3.2. Starting from the minimum measured value of t, called t_{min} , then select three values of t comprised within t_{min} and 1.05 t_{min} and calculate their arithmetical mean value t_m ,

then calculate: $z_m = \frac{0.566}{t_m}$

If it is demonstrated that for practical reasons the three values defined above cannot be obtained, then the minimum time t_{min} may be utilized. However, the requirements of paragraph 1.3. shall still apply.

1.1.4. The braking forces shall be calculated from the measured braking rate and the rolling resistance of the unbraked axle which is equal to 0.015 and 0.010 of the static axle load for a driven axle and a non-driven axle, respectively.

1.1.5. The dynamic load on the axle shall be that given by the formulae in annex 5 to this Regulation.

1.1.6. The value of k shall be rounded to three decimal places.

1.1.7. Then, the test will be repeated for the other axle(s) as defined in paragraphs 1.1.1. to 1.1.6. above.

1.1.8. For example, in the case of a two-axle rear-wheel drive vehicle, with the front axle (1) being braked, the coefficient of adhesion (k) is given by:

$$k_f = \frac{z_m \cdot P \cdot g - 0.015 F_2}{F_1 + \frac{h}{E} \cdot z_m \cdot P \cdot g}$$

The other symbols (P, h, E) are defined in annex 5 to this Regulation.

1.1.9. One coefficient will be determined for the front axle k_f and one for the rear axle k_r .

1.2. Determination of the adhesion utilized (e)

1.2.1. The adhesion utilized (e) is defined as the quotient of the maximum braking rate with the anti-lock system operative (z_{AL}) and the coefficient of adhesion (k_M) i.e.,

$$e = \frac{z_{AL}}{k_M}$$

1.2.2. From an initial vehicle speed of 55 km/h, the maximum braking rate (z_{AL}) shall be measured with full cycling of the anti-lock braking system and based on the average value of three tests, as in paragraph 1.1.3. of this appendix, using the time taken for the speed to reduce from 45 km/h to 15 km/h, according to the following formula:

$$z_{AL} = \frac{0.849}{t_m}$$

1.2.3. The coefficient of adhesion k_M shall be determined by weighting with the dynamic axle loads.

$$k_M = \frac{k_f \cdot F_{fdyn} + k_r \cdot F_{rdyn}}{P \cdot g}$$

where:

$$F_{fdyn} = F_f + \frac{h}{E} \cdot z_{AL} \cdot P \cdot g$$

$$F_{rdyn} = F_r - \frac{h}{E} \cdot z_{AL} \cdot P \cdot g$$

1.2.4. The value of ε shall be rounded to two decimal places.

1.2.5. In the case of a vehicle equipped with an anti-lock system of categories 1 or 2, the value of z_{AL} will be based on the whole vehicle, with the anti-lock system in operation, and the adhesion utilized (ε) is given by the same formula quoted in paragraph 1.2.1. of this appendix.

1.2.6. In the case of a vehicle equipped with an anti-lock system of category 3, the value of z_{AL} will be measured on each axle which has at least one directly controlled wheel. For example, for a two-axle rear-wheel drive vehicle with an anti-lock system acting only on the rear axle (2), the adhesion utilized (ε) is given by:

$$\varepsilon_2 = \frac{z_{AL} \cdot P \cdot g - 0.010 F_1}{k_2 (F_2 - \frac{h}{E} \cdot z_{AL} \cdot P \cdot g)}$$

This calculation shall be made for each axle having at least one directly controlled wheel.

1.3. If $\varepsilon > 1.00$, the measurements of coefficients of adhesion shall be repeated.
A tolerance of 10% is accepted.

Annex 6 - Appendix 3

PERFORMANCE ON DIFFERING ADHESION SURFACES

1.1. The prescribed braking rate referred to in paragraph 5.3.5. of this annex may be calculated by reference to the measured coefficient of adhesion of the two surfaces on which this test is carried out. These two surfaces must satisfy the conditions prescribed in paragraph 5.3.4. of this annex.

1.2. The coefficient of adhesion (k_H and k_L) of the high- and low-adhesion surfaces, respectively, shall be determined in accordance with the provisions in paragraph 1.1. of appendix 2 to this annex.

1.3. The braking rate (z_{MALS}) for laden vehicles shall be:

$$z_{MALS} \geq 0.75 \left(\frac{4k_L + k_H}{5}\right) \text{ and } z_{MALS} \geq k_L$$

Annex 6 - Appendix 4

METHOD OF SELECTION OF THE LOW ADHESION SURFACE

1. Details of the coefficient of adhesion of the surface selected, as defined in paragraph 5.1.1.2. of this annex, must be given to the Technical Service.

1.1. These data must include a curve of the coefficient of adhesion versus slip (from 0 to 100 per cent slip) for a speed of approximately 40 km/h.

1.1.1. The maximum value of the curve will represent k_{peak} and the value at 100 per cent slip will represent k_{lock}.

1.1.2. The ratio R shall be determined as the quotient of the k_{peak} and k_{lock}.

$$R = \frac{k_{peak}}{k_{lock}}$$

1.1.3. The value of R shall be rounded to one decimal place.

1.1.4. The surface to be used must have a ratio R between 1.0 and 2.0 1/.

2. Prior to the tests, the Technical Service shall ensure that the selected surface meets the specified requirements and shall be informed of the following:

test method to determine R,
type of vehicle,
axle load and tyres (different loads and different tyres have to be tested and the results shown to the Technical Service which will decide if they are representative for the vehicle to be approved).

2.1. The value of R shall be mentioned in the test report.

The calibration of the surface has to be carried out at least once a year with a representative vehicle to verify the stability of R.

1/ Until such test surfaces become generally available, a ratio R up to 2.5 is acceptable, subject to discussion with the Technical Service.

Annex 7

INERTIA DYNAMOMETER TEST METHOD FOR BRAKE LININGS

1. GENERAL

1.1. The procedure described in this annex may be applied in the event of a modification of vehicle type resulting from the fitting of brake linings of another type to vehicles which have been approved in accordance with this Regulation.

1.2. The alternative types of brake linings shall be checked by comparing their performance with that obtained from the brake linings with which the vehicle was equipped at the time of approval and conforming to the components identified in the relevant information document, a model of which is given in annex 1 to this Regulation.

1.3. The Technical Authority responsible for conducting approval tests may at its discretion require comparison of the performance of the brake linings to be carried out in accordance with the relevant provisions contained in annex 3 to this Regulation.

1.4. Application for approval by comparison shall be made by the vehicle manufacturer or by his duly accredited representative.

1.5. In the context of this annex "vehicle" shall mean the vehicle type approved according to this Regulation and for which it is requested that the comparison shall be considered satisfactory.

2. TEST EQUIPMENT

2.1. A dynamometer having the following characteristics shall be used for the tests:

2.1.1. it shall be capable of generating the inertia required by paragraph 3.1. of this annex, and have the capacity to meet the requirements prescribed by paragraph 1.5. of annex 3 to this Regulation with respect to the Type-I fade test;

2.1.2. the brakes fitted shall be identical with those of the original vehicle type concerned;

2.1.3. air cooling, if provided, shall be in accordance with paragraph 3.4. of this annex;

2.1.4. the instrumentation for the test shall be capable of providing at least the following data;

2.1.4.1. a continuous recording of disc or drum rotational speed;

2.1.4.2. number of revolutions completed during a stop, to resolution not greater than one eighth of a revolution;

2.1.4.3. stop time;

2.1.4.4. a continuous recording of the temperature measured in the centre of the path swept by the lining or at mid-thickness of the disc or drum or lining;

2.1.4.5. a continuous recording of brake application control line pressure or force;

2.1.4.6. a continuous recording of brake output torque.

3. TEST CONDITIONS

3.1. The dynamometer shall be set as close as possible, with ± 5 per cent tolerance, to the rotary inertia equivalent to that part of the total inertia of the vehicle braked by the appropriate wheel(s) according to the following formula:

$$I = M R^2$$

where

I = rotational inertia (kgm^2)

R = dynamic tyre rolling radius (m)

M = that part of the maximum mass of the vehicle braked by the appropriate wheel(s). In the case of a single-ended dynamometer, this part shall be calculated from the design braking distribution when deceleration corresponds to the appropriate value given in paragraph 2.1.1.(A) of annex 3 to this Regulation.

3.2. The initial rotational speed of the inertia dynamometer shall correspond to the linear speed of the vehicle as prescribed in paragraph 2.1.1.(A) of annex 3 to this Regulation and shall be based on the dynamic rolling radius of the tyre.

3.3. Brake linings shall be at least 80 per cent bedded and shall not have exceeded a temperature of 180°C during the bedding procedure, or alternatively, at the vehicle manufacturer's request, be bedded in accordance with his recommendations.

3.4. Cooling air may be used, flowing over the brake in a direction perpendicular to its axis of rotation. The velocity of the cooling air flowing over the brake shall be not greater than 10 km/h. The temperature of the cooling air shall be the ambient temperature.

4. TEST PROCEDURE

4.1. Five sample sets of the brake lining shall be subjected to the comparison test; they shall be compared with five sets of linings conforming to the original components identified in the information document concerning the first approval of the vehicle type concerned.

4.2. Brake lining equivalence shall be based on a comparison of the results achieved using the test procedures prescribed in this annex and in accordance with the following requirements.

4.3. Type-0 cold performance test

4.3.1. Three brake applications shall be made when the initial temperature is below 100°C. The temperature shall be measured in accordance with the provisions of paragraph 2.1.4.4. of this annex.

4.3.2. Brake applications shall be made from an initial rotational speed equivalent to that given in paragraph 2.1.1.(A) of annex 3 to this Regulation, and the brake shall be applied to achieve a mean torque equivalent to the deceleration prescribed in that paragraph. In addition, tests shall also be carried out at several rotational speeds, the lowest being equivalent to 30 per cent of the maximum speed of the vehicle and the highest being equivalent to 80 per cent of that speed.

4.3.3. The mean braking torque recorded during the above cold performance tests on the linings being tested for the purpose of comparison shall, for the same input measurement, be within the test limits ± 15 per cent of the mean braking torque recorded with the brake linings conforming to the component identified in the relevant application for vehicle type approval.

4.4. Type-I test (fade test)

4.4.1. Heating procedure

4.4.1.1. Brake linings shall be tested according to the procedure given in paragraph 1.5.1. of annex 3 to this Regulation.

4.4.2. Hot performance

4.4.2.1. On completion of the tests required under paragraph 4.4.1. of this annex, the hot braking performance test specified in paragraph 1.5.2. of annex 3 to this Regulation shall be carried out.

4.4.2.2. The mean braking torque recorded during the above hot performance tests on the linings being tested for the purpose of comparison shall, for the same input measurement, be within the test limits ± 15 per cent of the mean braking torque recorded with the brake linings conforming to the component identified in the relevant application for vehicle type approval.

5. INSPECTION OF BRAKE LININGS

5.1. Brake linings shall be visually inspected on completion of the above tests to check that they are in satisfactory condition for continued use in normal service.